

THE ROLE OF MUSEUM COLLECTIONS IN ORNITHOLOGICAL RESEARCH

BY RICHARD L. ZUSI

Smithsonian Institution, Washington, D. C.

Periodically the curator of any large collection of birds must ponder the future course of development of the collections in his care in keeping with changing research needs. His plans will probably be influenced by limitations of budget, space, and assistance; and to varying degrees the development of the collection may be out of his control. The United States National Museum, for example, is a repository for birds collected for federal agencies and as such houses rich collections of North American birds from nineteenth century railroad surveys, boundary surveys, the Biological Survey, and other sources. Today it receives specimens from medical research units of several governmental departments engaged in the study of arthropod-borne viruses. Like other museums, the U. S. National Museum has acquired large collections from privately financed expeditions. Particularly in the past, the research of leading ornithologists was molded in part fortuitously by the advent of such collections simply because ornithological research consisted mainly of naming new forms, reporting on new collections, writing faunal works, and revising and classifying taxa. Even at the turn of the century, Robert Ridgway, an esteemed curator of birds at the U. S. National Museum, differentiated between scientific ornithology as practiced by the curator, and popular ornithology—the study of habits, songs, nesting and other aspects of life-histories. Charged with the responsibility of publishing the ornithological results of work by the government, he produced a taxonomic synthesis of North and Middle American birds, based largely upon the collections of others (Ridg-

way, 1901). This life work secured his reputation as a leading ornithologist.

It was during Ridgway's time, however, that study of the living bird began to take its place with taxonomy as truly scientific ornithology. Today a tabulation of research papers in a major American ornithological journal, *The Auk*, would show only about 25 percent that deal with classification and distribution; an even smaller percentage of these papers are authored by curators of museum collections. Although there has been a decline in the proportion of research projects based on specimens to those not requiring collections, the actual number of workers who rely on specimens for their research has not declined. Furthermore, specimens are now used not only for traditional research activities but also in connection with other aspects of the biology of birds. In general the research career of a museum curator is less influenced by incoming collections now than in the past; rather, collections are increasingly influenced by a curator's research. Ornithology has reached the stage where the curator, in planning the growth of his collections, must first decide what is worthwhile research.

Research on birds in museums has changed because of the breadth of achievement of scientific ornithology as defined by Ridgway. About 8700 species, and between three and four times that many subspecies of birds are presently recognized; in the past ten years only about 5 new species and some 30 subspecies have been described per year. Some of these new species were recognized through restudy of museum specimens; others were taken in the field by collectors working in new areas—today notably within Peru and the Philippines. In general, however, the description of new species is no longer an important ornithological activity in that classifications are rarely upset by the addition of the new forms. By contrast, the description of fossil forms continues to provide new insights into adaptive radiations of the past.

The general outlines of geographical distribution of birds are known; indeed the final volumes of a distributional check-list of the species and subspecies of birds of the world begun in 1931 by James L. Peters are now nearing completion (Peters, 1931). In addition to systematic and faunal treatises for most

regions of the world we now have well illustrated pocket field guides for such areas as Argentina, Mexico, the West Indies, North America, Europe, Russia, East Africa, South Vietnam, Thailand, Japan, New Zealand, and the oceans. Most major collections in larger American museums have been documented in reports of one kind or another, and many of the larger families of birds have received taxonomic revision in the last 50 years, some indeed receiving multiple treatment.

What then, are the current directions of ornithological research? Although description of new forms has tapered off there is still considerable interest in distributional and faunal problems, particularly concerning South America, Africa, and tropical Asia. In addition, systematic work continues apace with ever-changing concepts and methods (see Sibley, 1955; Mayr, 1959). The museum worker of today thinks very differently from his counterpart of 100 years ago and he uses such varied approaches to systematics as comparative biochemistry, behavior, song structure, and functional anatomy, as well as the more traditional ones. Museum workers and others using collections have also dealt with the analysis of population variation and modes of speciation using large samples and quantitative methods, with the adaptive significance of anatomical structures, with modes of evolution on islands, with the origin and history of avifaunas, and with a variety of other problems. Although the limits of higher categories of birds are well established the phylogenetic relationships of the families and orders are little understood; these are being studied from the viewpoints of comparative anatomy, behavior, and biochemistry. There have been recent attempts to understand the adaptive significance of the diverse patterns of reproductive biology, migration, and molt, that have been described from the study of specimens and living birds. Variation in characters such as bill and wing length, measured on study skins, is playing a role in the development of ecological theory, particularly in regard to concepts of niche, competition, and species diversity. It is because of the increasing emphasis on comparative biology of birds on the part of workers who utilize specimens that we should reexamine the nature of our specimens and collections

to see that they continue to serve traditional functions and at the same time meet new needs.

The nature of the specimen itself in part determines its usefulness or potential as a research tool. A typical bird specimen is made by removing and discarding nine of the bird's ten organ systems, filling the remaining integumentary system with cotton, sewing it up in such a way that the inner portion of the wings can never be studied, and affixing a label. In another kind of preparation, nine organ systems are again discarded, leaving only the skeletal system. Skeletons are not emphasized in most bird collections although their importance is gaining in many museums. Still less in favor is the spirit specimen—a bird with all ten organ systems intact and preserved in alcohol. The early skeleton and spirit collections, often abhorrent to the skin taxonomist, owe their existence less to ornithologists than to workers in museum divisions of comparative anatomy. Other specimens once of great moment but now rarely consulted are the empty egg shells and the empty nests. All of these preparations are the traditional tools of the ornithological curator's trade.

For a single organ system, the bird's skin and feathers contain much information; it is this part of the bird that meets the environment and this part to which other birds react. Feathers are therefore subjected to many selection pressures and they have evolved an enormous diversity of structure, pigment, pattern, and molt sequences. (Because feathers of the folded wings of a bird skin are difficult or impossible to study, the molt pattern of the wings should be routinely recorded on specimen labels, and some spread-wing specimens should be prepared.) Taxonomic information from the integumentary system applies chiefly to relationships at the infraspecific and specific levels because differences often reflect geographic isolation, or the need for reproductive isolation between closely related sympatric forms. Plumage patterns are fairly stable in some groups, thereby serving also as indicators of generic relationships.

In the bird's skeleton the long history of common descent within an order or family is often reflected by peculiarities of the relationships of bones. In addition, by its proportions the

skeleton strongly reflects behavior patterns of feeding and locomotion that may characterize related groups or unrelated ecological counterparts. Comparative and functional osteology therefore have served as useful bases for establishing the higher taxonomic levels and for understanding structural adaptation.

Spirit specimens, like skeletons, have provided important foundations for delineating higher taxa through comparative anatomy (for example see Fürbringer, 1888), and will probably retain their importance for future studies of phylogenetic relationships.

In the past, skins were studied by taxonomists—skeletons and spirit specimens by anatomists. Anatomists (and paleontologists) had to be content with the few anatomical specimens that were prepared along with the multitudes of skins obtained on expeditions. Anatomists have therefore become used to working with one or a few specimens, often with incomplete data, but many skeletons (preferably at least ten of each sex) are needed to encompass natural variation and to avoid erroneous conclusions based on artifacts of preparation. Spirit specimens are also needed in large series because several organ systems may be destroyed during dissection of any one system. Some collectors “pickle” specimens that are too damaged to skin, when in fact there is nothing more useless than a badly damaged anatomical specimen. The data vital for skin labels are equally vital for anatomical specimens. Today anatomists are a vanishing breed, but many ornithologists undertake anatomical studies for the solution of ornithological problems. It is increasingly apparent that many questions in avian biology and taxonomy cannot be answered by using skin collections alone. The traditional skin collection should therefore give way to balanced collections for each species, including skins, skeletons, and spirit specimens, as well as neonatal young, eggs, and nests. Any curator who fails to develop all of these kinds of collections is simply limiting the research potential of the museum at a time when the need for diversity of approach to problems is rapidly increasing.

To a limited degree wholly new kinds of collections are becoming a part of the ornithologist's bag of tools. The Library of Natural Sounds at Cornell University, containing about 300

miles of tape, can be called upon for comparative study of bird songs. Files of X-rays may be regarded as supplementary collections, and slide collections of comparative histology will probably be available some day. Samples of egg whites and blood may be stored temporarily until permanent records of their chemical properties are made and filed. Comparative study of birds in the field is like an extension of the specimen, especially when documented by photographs or motion pictures. Methods of storing and making available such new "specimens" are in general not well developed.

Having examined the specimens let us now look at the merits and demerits of different kinds of collections in the light of present research trends. Collections made today or in the future are likely to be of three different sorts: Those of a general nature made with no biological problem in mind but intended to increase representation of certain portions of a museum's holdings; collections designed for the solution of a particular ornithological problem; collections designed for the solution of a non-ornithological problem. The need for general collections from all parts of the world has diminished with the advancing development of traditional ornithology, but the need for improving world-wide representation in the larger museums and regional representation in smaller museums continues because of the value of collections as seed sources for ideas. In other words, although it is often possible to assemble enough specimens from many museums to answer a given question, the question might not have been asked without sufficient representation of species or specimens in any one museum to show that a problem existed. Important research museums should therefore inventory their holdings and attempt to fill in gaps within the overall scope of their collections. This job could be done by a collection manager and trained collectors, leaving the research curator free to specialize.

Collections intended to solve a problem, whether or not an ornithological one, are sometimes analogous to a laboratory experiment in which most of the variables are controlled. Birds vary by age, sex, season, color phase, geographical origin, ecological situation, and physiological cycle. To study the causes and properties of any one variable the other variables can be

minimized by selective collecting. Only in a specialized collection are adequate series of the critical specimens likely to be obtained. Examples of such collections are: sibling species taken just after their complete molt for comparison of subtle color differences in fresh feathers; series taken across zones of allopatric hybridization for study of gene flow in populations; specimens taken at regular time intervals throughout the year to determine the molt and breeding regimen of a population; comprehensive collections from a given locality and season for ecological or faunal comparisons with other such collections.

Examples of non-ornithological problems requiring collections are: determination of the role of a given species or regional population of birds in carrying viruses or their arthropod vectors; evaluation of the involvement of a species or local avifauna in the destruction of an agricultural crop. Here the virus, parasite, or stomach contents are the primary collections whereas the bird specimen may be retained only for species verification. The ornithological value of such studies could be slight or great depending on the degree to which factors of ornithological importance were added to the initial research objectives.

Specimens derived from a specialized project will, in some cases, be obtained in much larger series than necessary to fill in the desired representation in the museum's general collection. This is particularly vexing when large birds are involved. If space is a problem one could argue for discarding such specimens at the conclusion of the study on the grounds that their intended purpose had been served. For reasons mentioned later I believe they should be retained or distributed to other museums.

What sorts of data should be associated with specimens in future collections to enhance their usefulness for research? This question has been dealt with in different ways by others (for example, Miller, 1940; Van Tyne, 1952; Parkes, 1963). Traditionally, the principal data recorded with each specimen has been the locality, date, sex, and collector. Of these, the first three, and to a lesser extent the last, are objective data that everyone can (usually) interpret without ambiguity. Other types of data are often added to the label today, as they were indeed

by some of the earlier collectors—skin colors, weight, amount of fat, stomach contents, presence of brood patch, breeding condition, molt, etc. Some of these data are subjective in that they can be misinterpreted by a research worker unless they were carefully qualified or described by the preparator. For example, body weight may be recorded to a tenth of a gram—but how fat was the bird, and how much did the fish in its stomach weigh? Body feathers may be said to be molting, but was the bird really molting or was it just replacing some feathers lost accidentally? What unrecorded soft or liquid foods were eaten, leaving no trace in the stomach? Does “testes enlarged” necessarily indicate breeding and does “skull unossified” indicate immaturity? Such data are of greatest use when qualified so as to minimize their subjectivity. Subjective data should not be confused with items such as “sex,” the determination of which requires recognition of sometimes tiny and confusing internal organs and is therefore subject to error, but not to interpretation.

The integrity of the specimen label determines the scientific usefulness of the specimen and of the collection. Data on labels are subject to errors stemming from carelessness, ignorance, and fraud. To reduce errors of carelessness the label should be made out at the time of collection and preparation, and attached to the specimen by the preparator rather than transcribed from a field book by someone else later, and associated with the specimen on the basis of a field number. Errors of ignorance can be reduced (and subjective data enhanced) by training collectors in those aspects of avian biology that are pertinent to the production of a useful label. Knowledge of the source of data on a label can be useful to the scientist in judging the likelihood of errors of all kinds and it follows that the name of each person who records data must appear clearly on the label. In collections made for non-ornithological purposes or in large ornithological expeditions it is sometimes the case that only the name of the project, or the sponsor, or the principal investigator, appears on the label. One is then at a loss to know who recorded the data.

In an attempt to facilitate research and curation of certain collections, the Smithsonian Institution is developing an elec-

tronic data processing system (EDP) capable of storing, sorting and printing out much of the data associated with specimens (Galler, et al., 1968). The advent of computer technology may seem to be an argument for amassing more general collections with more data on the labels because the computer is capable of sorting and combining voluminous amounts and diverse kinds of information. The research value of an EDP printout, however, is limited by the accuracy of the data and by the difficulties inherent in subjective data, compounded by the nagging possibility of operational errors. There is the danger that printouts of specimen data, if readily available, would generate a rash of research based on printouts without reference to the specimens—hence without critical evaluation of the accuracy, reliability, or significance of the data. Many questions will not be answerable by the data selected for inclusion in EDP; any attempt to rectify this difficulty by recording “complete” data in the field is self-limiting in that it would leave little time to obtain and prepare specimens. Specialized data cannot be gathered by untrained assistants. The alleged research and curatorial values of computerizing all museum collections are limited by these and other difficulties, and they must be weighed against the costs (in time and money) of setting up and operating the system. Although the practicality of a shot-gun application of EDP to all ornithological collections is doubtful, data processing could be a useful tool in some research projects if the data were gathered in such a way that important questions could be answered within the capabilities and limitations of the machine.

As a preliminary step in planning research on museum specimens it would be useful to know in which museums or collections the desired specimens could be found. This need could be most simply satisfied if each museum were to publish an inventory of its holdings by species (or subspecies if possible). More useful would be a composite inventory of all museum collections following the form of the Union List of Serials, in which the serials would be replaced by bird species (or subspecies), and the libraries by museums (with a rough indication of numbers of specimens). Even an incomplete compendium would be immediately useful and would gain in

importance as additional museums incorporated their inventories. This would be a modest undertaking compared with the Union List of Serials, which records the representation of over 150,000 titles in 956 cooperating libraries.

In ornithology I anticipate that general collecting will continue to decline as all portions of the world become better represented by specimens, and that incoming collections will be geared more for answering particular biological questions than for producing conventional collection reports. I believe, however, that a balance between general and special collections should be maintained because of the value of general collections for bringing to light the unexpected.

Curators will have to decide whether or not to retain special bird collections that have served their purpose in answering a particular problem. In deciding we must remember that collections cannot be duplicated with the ease of a chemist duplicating a precipitate and that their research potential surely exceeds that realized in any one study. In some respects their usefulness increases with time; over a period of 50, 500, or 1000 years specimens may, like fossils, provide the evidence for evolutionary change and rates. (After all, what are fossils but skeleton collections that have been housed in rock rather than boxes?) Also, specimens become important historical documents as particular environments on earth are changed or lost. Another reason for retaining collections is that the published word represents opinion and is subject to error; as ideas change and as the literature becomes distrusted after a period of years reference to the specimen is required again (Berlioz, 1960). If a museum cannot provide accessible storage space for increasing collections an effort should be made to distribute at least parts of long series to other museums or to teaching institutions.

Emphasis in museum ornithology will probably remain for some time on various aspects of the comparative biology of birds and on the processes of speciation and differentiation of the higher categories—problems that may be served by someone working in behavior, ecology, ecological physiology, cytogenetics, or biochemistry as well as in more traditional aspects of systematics. To justify occupying a museum position, how-

ever, a curator should apply his interests toward understanding the diversity of birds through comparative studies that in some way derive support from collections. Diversity of approach to collections may be the key to continued viability of museum research as we expand from traditional functions into comparative biology.

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